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Typed Name: Kevin D. McCarthy
Date: November 25, 2009

Patent 0-06-168 (17110/US/04)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Morgenstein
Serial no.:	10/587,557
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Title:	THERMAL TO ELECTRICAL ENERGY CONVERTER
Examiner:	Jayne L. Mershon
Art Unit:	1795
Confirmation:	8920

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir/Madam:

RESPONSE

This response is in reply to the office action mailed on August 27, 2009.

1. Claim Rejections under 35 U.S.C. §112: The Examiner has rejected claims 4 and 6 under 35 U.S.C. §112 as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

Specifically the Examiner finds indefinite the use of the terms "inlet conduit" and "outlet conduit" in these claims. It is respectfully noted by the Applicant that the terms 'outlet conduit' and 'inlet conduit' have been clearly defined in paragraphs [0016] and [0018] respectively of the application. An "outlet conduit" (118 in Fig. 1 and Fig. 5; 220 in Fig. 2 and Fig. 6) conveys ferrofluid from the HDC to the HAC. An "inlet conduit" (120 in Fig. 1 and Fig. 5; 214 in Fig. 2 and Fig. 6) conveys ferrofluid from the HAC to the HDC.

Fig. 6 shows the relationship between inlet conduit 214, outlet conduit 220, and booster conduit 219 (paragraph [0120] of the application) that is the subject matter of claim 6.

Applicant requests that the Examiner reconsider and withdraw her rejections of claims 4 and 6 in view of this explanation.

2. Claim Rejections under 35 U.S.C. §103: The Examiner has rejected claims 1-9 and 14-20 under 35 U.S.C. §103(a) as being unpatentable over Redman (U.S. 4,064,409) in view of George, Jr. (U.S. 6,651,433) and has rejected claims 10-13 and

21 under 35 U.S.C. §103(a) as being unpatentable over Redman and George, Jr. in further view of Weimer et al. (U.S. 2003/0208959).

A. A brief summary the present application:

The invention is a converter for converting thermal energy into electrical energy. The main components of the converter are a chamber where heat is absorbed from an external source, another chamber where heat is dissipated to an external heat sink, a reservoir tank for regulating the ferrofluid in order to adapt the circuit for operation in a wide range of possible operating conditions and may also cool the ferrofluid when required, valves that enable timely separation of different sections of the converter, and conduits connecting the two chambers to form a closed circuit around which a ferrofluid circulates and connecting the reservoir to the circuit to adjust the ferrofluid flow.

The energy conversion takes place by causing magnetic particles that are initially suspended in the ferrofluid to circulate in the converter and to induce electric currents when they pass through one or more coils of electric wires that are coiled around parts of the conduits of the converter. In order to maximize the energy conversion, magnets are provided to align the magnetic fields of the magnetic particles before they enter the coils of electric wires.

The particles are caused to circulate around the main circuit of the converter in a pulsed mode by timely activation of valves located at strategic locations in the converter, thereby controlling the thermodynamic conditions of each of the separated sections of the circuit. It is the generated differences in pressure that are primarily responsible for the motive force causing the magnetic particles to move around the closed circuit.

The valves are timely activated such as to enable ferrofluid flow from the heat absorbing chamber when it is at a required high pressure to the heat dissipating chamber at the low pressure, and to reverse the flow at the next stage in order to timely maintain a pulsed flow of the magnetic particles around the entire closed circuit of the converter. The reservoir container may also help regulate the circuit pressures and may further enable cooling of the ferrofluid when required, thus being an imperative component for enablement of the general operation and operation efficiency of the converter at different power conversion levels.

B. A brief summary of Redman:

The invention described in this patent is an apparatus in which a ferrofluid is caused to circulate around a continuous closed circuit. At one point in the circuit, heat from an external source is used to vaporize the liquid component of the ferrofluid from a reservoir. The vapor passes through a Venturi stage, which is adapted so that the magnetic particles are carried along in the vapor stream. Electricity is produced when the magnetic particles in the vapor stream pass through coils of wire. After passing through the coils, the vapor enters a heat exchanger where it is condensed to liquid ferrofluid.

There are no valves in the system; therefore the pressure differences in the circuit are comparably small. The motive force that causes the ferrofluid to move around the circuit is provided by a ring magnet which attracts the magnetic particles in the ferrofluid pulling them towards the reservoir and a venturi stage which injects the ferrofluid into the vapor, and could further be provided by a "wick" which uses capillary pumping of the ferrofluid.

C. A brief summary of George, Jr.:

The invention described in this patent is an internal combustion engine coupled to a bottoming system as well as fuel and oxygen (for closed environments) supplies and water based cooling provided to the bottoming system. The bottoming system section performs energy conversion by converting heat of the exhaust gases from a variety of possible internal combustion engines and stores the power in a number of possible forms or transfers it back to the engine.

The system recovers heat from the exhaust of internal combustion engines by means of an open or closed bottoming cycle utilizing the compression and expansion of the working fluid. In a closed cycle, such as in submarines or in a mine vehicle, the working fluid might be an inert gaseous fluid such as helium, nitrogen or carbon dioxide and for an open cycle air is used. The system makes use of a compressor-turbine combination and a motor/generator as well as additions of a thermal battery and a compressed gas tank.

D. The arguments and remarks regarding the comparison made by the Examiner between the systems of Redman and George, Jr. and the combination thereof with the invention of the present application:

a. Similarly to the present invention Redman teaches a method of causing magnetic particles to flow around a closed circuit and through a coil of electric wire in which an electric current is induced.

One difference between the teaching of Redman and the present invention is the method in which the magnetic particles are moved around the circuit. Redman relies on a ring magnet, which attracts the magnetic particles in the ferrofluid, and a venturi stage as well as possible capillary pumping of the ferrofluid, which attracts the magnetic particles in the ferrofluid. The apparatus provides a constant flow of particles through the coil to provide constant DC electrical power. In the present invention the flow around the circuit is precisely controlled, by means of a controller, in order to create the required pressure differences between the isolated parts of the circuit. The pressure at each isolated part of the circuit is thus accurately regulated by the controller which timely opens and closes a plurality of valves at different locations in the circuit. The result is a system using a batch process, as accurately pointed out by the Examiner, which provides a non-continuous flow, i.e. the flow is in the form of short pulses, of magnetic particles through the coils resulting in the generation of AC electrical power.

Redman uses a continuous circuit rather than isolated sections with physical and thermodynamic separation between the sections that is adapted for pulsed operation and conversion of heat to AC electrical power in the present invention.

Thermodynamically, the system of Redman describes a standard continuous cycle wherein work is extracted in the form of electrical energy instead of mechanical energy, such as in a more typical cycle of this type. The working fluid transfers heat from the heat source to the cold sink while transforming some of the heat into useful work in the process. The working fluid further uses some of the heat and an electromotive force provided by a magnet to maintain the cycle.

The system of the present invention is far different from the above. By selectively and timely separating the different sections of the circuit, the system enables the thermodynamic conditions of the ferrofluid in each section to change, and then transfers it to the next section. A batch process such as this has multiple advantages as herein described.

b. The Examiner has dismissed the reservoir as being "simply a larger heat exchanger portion" and therefore a trivial design change. This is not the case. The

addition of a reservoir enables a far greater operative range, and optimal operation throughout most of that range, with the circuit's isolated thermodynamic conditions and corresponding valve opening and closing timing adapted for such optimal performance. This is especially important for applications wherein renewable energy sources act as the heat source (i.e. solar radiation, wind, waves, water flow, geothermal), since such sources typically do not provide constant or continuous energy output. This includes very low or high temperature differences and heat input and power output values.

Since the amount of ferrofluid in the entire system is constant, when a quantity of ferrofluid is "trapped" in the reservoir the amount of ferrofluid available in the rest of the system is reduced. Therefore the overall pressure in the system is reduced and boiling of the ferrofluid in the HAC and overall efficiency of operation of the system can take place at lower temperatures. The opposite situation occurs when ferrofluid is released from the reservoir. The reservoir is not a part of a condenser that has been made "separable from the main circulation system, rather than integral" as stated in the Office Action. The reservoir fulfills a vital function in controlling the operation and operating condition of the power generation system. It can only fulfill this function as a separate unit that is connected and disconnected to the main circuit by means of a valve that can be opened and closed to allow ferrofluid to enter or exit it as required.

The reservoir is operable in a plurality of ways in order to achieve the goal of optimizing the system performance. For example, it may be full or empty or partially filled, it may be operable in sequence with the timely cycles of the circuit or be separated from the main circuit by a closed valve until a change in the amount of ferrofluid is called for at a later time when there is sufficient change in the heat input by the external heat source. Even when the reservoir optionally works in a cyclic manner in tandem with the circuit, it can be at a different temperature and the ferrofluid in it can be in a different thermodynamic state. The system of Redman comprises a reservoir 109, but the system would not be able to operate at all if the reservoir of Redman were operated in any of the above ways. Furthermore, the reservoir of Redman is part of the heat absorbing section at the 'hot side' of the system, whereas the reservoir of the present invention is located at the 'cold side' of the system.

c. The invention of the present application operates on the basis of a controlled and discontinuous thermo-electric cycle which enables regulation of the power conversion process to maximize the efficiency of the converter far beyond that of Redman. The apparatus of Redman has neither an isolated heat absorbing container nor an isolated heat dissipating container that through their timely isolation from the rest of the system allow the temperatures and pressures in the containers to rise/decrease over a very wide range as required from the present invention. It would further be apparent to one skilled in the art that Redman's converter has to have a far more massive and voluminous structure to enable a similar power transfer rate due to the lack of isolated heat exchangers which can accordingly be designed with maximum efficiency as in the present invention.

d. The apparatus of Redman is self-regulated, i.e. within its operable range it operates without control means other than the heat input and output at the 'hot side' and 'cold side' respectively. While the addition of a fluid reservoir and a controller for connecting the reservoir to the apparatus could theoretically enable one to considerably expand the operable range of the apparatus and speed up the self-regulation, such an addition can hardly be made without major modifications to the design of the system and has not been suggested by Redman in any way.

e. The system of the present invention enables the extraction of AC electrical power both when the fluid passes from HAC to HDC and on the return path instead of requiring an active power consuming means to return the cooled fluid to the HAC.

f. Fast flow pulses of ferrofluid through the coils significantly increase the efficiency of electrical energy generation. Even though faster flow speed may also be achieved in a continuous cycle such as that of Redman, this will require either considerably increasing the size of the heat exchangers or decreasing their efficiency or both.

g. The system of the present invention enables the frequency and power output to be interchangeably adapted when required. AC electrical power is adapted to more types of applications and may directly be connected to an external power grid

without the additional need for transformers for DC to AC electrical power transformation.

h. The Examiner takes the position that "it would be obvious for a person having ordinary skill in the art to modify the self-pumping closed loop system in Redman with a closed loop system that operated in a batch style by adding valves because the valves force expansion when heated and creates liquid movement in a reliable and predictable manner." Applicant disagrees with this. In the first place there are no obvious locations in Redman to place valves. In the second place the liquid movement in the system of Redman is continuous and therefore (assuming that the system works) continuous and reliable. Addition of valves would only disrupt the continuous flow therefore there is no motivation to do this. Finally introduction of a pulsed mode into the system of Redman would, at a minimum disrupt the capillary forces that help move the ferrofluid through wick portion 7 of the circuit and also most probably disrupt the ability of magnet 3 to function as described.

i. In the present invention magnetic field generation elements for aligning the magnetic fields of the magnetic particles in the ferrofluid are provided at the location of the coils of wire in which the electricity is generated. This is a critical feature necessary to achieve the goal of the invention. It has been found that the orientation of the magnet fields of the particles in the ferrofluid stream almost instantaneously becomes random in the absence of a magnetic field that forces the alignment.

In the embodiment of Redman shown in Fig. 1, the only element that could possibly fulfill the function of aligning the magnetic fields of the particles is magnet 3. However, this magnet is located before the venturi section well before solenoid 5 and therefore the magnetic fields of the magnetic particles in the ferrofluid that pass through the solenoid are randomly aligned resulting in very poor (if any) production of electricity. Redman apparently recognized this problem because he describes an embodiment shown in Fig. 4. In this embodiment he supplies toroidal magnet 103 just before solenoid 105. This is an improvement over the embodiment of Fig. 1, but still will result in significantly lower electricity output than placement of the magnetic field generation elements as taught in the present invention. It is also noted that the use of the term "toroidal magnet" to describe element 103 implies that this is an

electromagnet, which will require electric power to operate, thereby reducing the overall output of the system.

j. Regarding the system of George, Jr., it is respectfully noted that the fluid heater 44 of George, Jr., which has been referred to by the Examiner, is only a gas heater, and not a liquid heater. Similarly, the thermal battery section 43 and heat exchanger 40 as well as the whole energy converting section, i.e. bottoming system, of George, Jr. uses a gaseous fluid, such as: helium, nitrogen or carbon dioxide for a closed cycle and air for an open cycle. Thus, not only does the system of George, Jr. not make use of a ferrofluid with magnetic properties, it also does not transform its working fluid into liquid state nor later vaporize it later in the cycle. The advantages of using a working fluid in a liquid state according to the Rankine cycle as opposed to using a gas in a Carnot cycle are well known in the art, and thus employed in most power plants. These advantages include for example general conversion efficiency and volumetric efficiency.

The system of the present invention is more efficient when compared to a Rankine cycle because its thermodynamic cycle is discontinuous (accomplished by means of the timely opening and closing of the valves) Consequently a compressor or other energy consuming means is not required to transfer the ferrofluid from the HDC to the HAC but rather more electrical power is generated in this process instead. Additionally the pressure and temperature differences between the HAC and HDC can be in a far wider range than for either Redman or George Jr.

k. The system of George, Jr. is continuous in its operation. This is a basic requirement for a turbine-compressor combination. Such a system is neither designed nor capable of operating with pulsed fluid flow at any reasonable level of efficiency and can not exploit the benefits of such operation. Nor is it intended to operate with pulsed fluid flow since its mission is to convert heat into mechanical energy, DC power, heat stored in a thermal battery, or a compressed gas tank or a combination of these in order to provide the converted energy for the needs of a general internal combustion engine system.

l. The Examiner expresses the opinion that the fluid heater 44 of George, Jr. is comparable to the reservoir of the present invention. The Applicant would like

to point out that as is described in the relevant paragraph to which the lines quoted by the Examiner belong (Col. 7, line 57 – Col. 8, line 21), the working fluid is still being heated, rather than cooled, in fluid heater 44. Furthermore the heater is part of the 'hot side' of the cycle – prior to the turbine. Certainly no condensation occurs in the permanently gaseous fluid of the bottoming system described by George, Jr. Had it occurred – it would occur during the exit of the working fluid from the turbine or at a later stage and before it is heated and vaporized again in order to begin a new cycle.

m. The system of George, Jr., when compared to the system of the present invention, has a very limited operation range. Well known and strict limitations are imposed on the absolute pressures as well as pressure ratios of the system due to the use of limiting mechanical means, i.e. turbine-compressor combination, for power output and optimum energy conversion efficiency is both lower and can be achieved in only small ranges of operating conditions with comparably very poor adjustment options.

The system of George, Jr. can not function for low temperatures achieved at the heat exchanger and low temperature differences between the hot and cold sides of the converter, even by far more so than the apparatus of Redman. Whereas, the system of the present invention can function well even at very low temperature differences through the use of timely opening and closing valves to regulate the flow of the fluid through different parts of the cycle, enabling its vaporization and condensation.

n. The role of the valves in the bottoming section of the system of George, Jr. is to:

i. Adjust working fluid flow to and from the thermal battery 236.
ii. Adjust working fluid flow to and from the heat exchanger 40.
iii. Adjust working fluid flow to and from high pressure storage tank 107 (when such is present).
iv. Adjust the compression ratios of the compressors.
v. Adjust working fluid flow out of the system.

For each mode of operation, these valves have a predefined (open) state in which they stay for the duration of that operation mode, as long as the inputs and outputs of the engine and motors/generators remain the same.

The Examiner has referred to Col 8, lines 26-43 of George, Jr. wherein are disclosed the modulation valves 98 and 99 of compressors 86 and 95, respectively. These valves are devices that generally do not prevent the gas flow through the compressor but only adjust it so as to achieve the required compression ratios out of the available operation range of each screw compressor, and they are also integral parts of the compressors. These are completely different devices from those of the present invention, which are simple pressurized gas/fluid valves having a nozzle through which gas/fluid flows in the 'open' state and means for blocking the gas/fluid flow in the 'closed' state, and not being part of other devices.

o. The Examiner further expresses the opinion that the present invention has similar components to those of the system of George, Jr. The Applicant respectfully begs to remind the Examiner that the present invention has no separate compressors or heat exchangers, much less ones that are adapted to operate with gas as the primary working fluid. Due to the separated operation of different sections of the present invention both compression and positive or negative heat exchange is achieved in the HAC or HDC, which are essentially boiler or cooler containers where much of the working fluid is in a liquid state.

Even further, the bottoming system section of the system of George, Jr. has to make use of not only of heat exchanger adapted for use with a gas stream but also of intercoolers, due to the gaseous nature of the working fluid. Neither of these components are necessary in the case of the present invention.

p. Redman uses electromotive means, capillary action, and injection through a venturi stage to circulate the ferrofluid. George, Jr. uses mechanical means such as a compressor to operate a standard thermodynamic circuit. The invention uses a controlled process wherein valves are controlled in a timely manner to execute expansion following the cyclically built pressure gradient on opposite sides of the valves at different sections of the circuit.

q. The Applicant believes that the above arguments present a thorough explanation which clearly shows that the system of George, Jr., as well as individual sections of it - the more relevant of which is the bottoming system referred to by the Examiner, is generally very far from the system of the present invention. It is a mechanical system using a turbine-compressor configuration and operating continuously using a gaseous working fluid to perform mechanical work or transfer heat which may then be converted into other energy forms in totally different manner from the system of the present invention.

r. There are many other differences between the system of the present invention and the systems of Redman and George, Jr., either considered alone or in combination, but the Applicant believes that the abovementioned very significant differences are enough to show inventiveness of the independent Claim 1 of the present application.

E. Conclusion:

a. Unless the objective was to duplicate the system of the present invention, the Applicant finds no explanation in the Office Action of why a skilled person, at the time of the invention, i.e. before the details of the system of the present invention were known to the public, would want to modify the apparatus of Redman. What technical problem would he solve by modifying Redman? The only answer to this question that occurs to the Applicant is "to improve the electricity output from the system of Redman". But if this were the problem that the skilled person were trying to solve there are many ways to accomplish this, e.g. increase the concentration of magnetic particles in the ferrofluid or increase the flow rate, without major modification to the system.

The subject matter of Redman relates to the generation of electric power (IPC code H02). The subject matter of George Jr. relates to engines (IPC code F01). It is not clear that the person skilled in one of these fields would have the same skill in the other. There would be no reason to look to a document from the field of power systems for internal combustion engines to find ways to improve the operation of a system that relies on creating temperature differentials in different parts of a closed circuit to generate electricity. The Examiner has provided no explanation for why the

hypothetical skilled person who wanted to make some hypothetical change in the system for some hypothetical reason would look to George Jr.

b. Despite what is said in the previous paragraph, if nonetheless the person skilled in the art relevant to Redman were to combining selected parts of the system of George Jr. with the system of Redman (assuming that such a combination is at all possible considering the vast differences between them) the result will not be the system of the invention. In particular it is not at all clear how incorporating the gas heater of George, Jr. which has no similar equivalent in the present invention, or valves, such as those described in George Jr., at different parts in the circuit of Redmond could be accomplished. For example, where exactly would the valves be placed and how would they be operated? The system of Redmond relies on a continuous flow of ferrofluid around the circuit, therefore it seems that if the system of Redmond were modified by adding valves that open and close at predetermined intervals as suggested by the Examiner, it would no longer work.

c. It is clear that combining the systems of Redman and George, Jr. as proposed by the Examiner will not form a system which is even close to the system of the present invention. This is because neither of the two cited references teaches any of at least the following features of claim 1 of the present invention: an isolated heat absorbing container, an isolated heat dissipating container, control means to operate the timely opening and closing of valves, and magnetic field generation elements for aligning the magnetic fields of the particles located coaxially with the coils of wire in which the electricity is produced. This being the case, independent claim 1 is inventive over the cited prior art patents either taken alone or in combination.

d. The Dependent Claims 2-14 are either directly or indirectly dependent on independent claim 1, are therefore also not made obvious by Redman in view of George, Jr.

e. Independent claim 15 is a method for operating the system of claim 1 and the arguments presented above can be applied *mutatis mutandis* to show the inventiveness of claim 15 over the cited prior art. Claims 16-21 are either directly or indirectly

dependent on independent claim 15, and therefore are also inventive over the cited prior art.

In view of all of the above, Applicant respectfully requests that the Examiner reconsider her objections and allow the claims of the application.

Respectfully submitted

Kevin D. McCarthy

Kevin D. McCarthy
Reg. No. 35,278

Roach, Brown, McCarthy & Gruber, P.C.
1920 Liberty Building - 424 Main Street
Buffalo, New York 14202